Connection of the Spots with Prominences.

In 1869, when a sun-spot maximum was approaching, the prominences were classified by one of us into *eruptive* and *nebulous;* the former showing many metallic lines, the latter the hydrogen and helium lines chiefly. This conclusion, which was published in 1870, was subsequently confirmed and adopted by Secchi, Zöllner, Spörer, Young and Respighi.

In the same year prominences on the sun's disc were also observed by one of us by means of the C and F lines.[1]

The eruptive prominences, unlike the nebulous ones, were not observed in all heliographic latitudes; but, according to the extended observations of Tacchini and Ricco, had their maxima in the same latitude as the spots. This is especially well shown by the diagrams illustrating the distribution of spots, faculæ, eruptions and protuberances which are given by Tacchini for 1881–1887 in the *Memoria della Soc. degli Spettroscopisti Italiani*, 1882–1888. These curves show in the most unmistak able manner that the spots, faculæ and eruptive or metallic prominences have their maximum frequency in the same solar latitudes while the nebulous or quiet prominences are more uniformly distributed, and even have maxima in zones where spots are rarely observed. This is corroborated by what Prof. Respighi many years ago stated:

"In correspondence with the maximum of spots, not only does the number of the large protuberances increase, but more than this—their distribution over the solar surface is radically modified."

In his observations, Prof. Young found that the H and K lines of calcium were reversed in the chromosphere as constantly as *h* or C, and the same lines "were also found to be regularly reversed upon the body of the sun itself, in the penumbra and immediate neighbourhood of every important spot."[2] This result was confirmed by the early (1881) attempts of one of us to photograph the spectra of the chromosphere and spots, and also by eclipse photographs. In the photographic spectrum, the H and K lines are by far the brightest of the chromospheric lines, and this fact has been utilised by Hale and Deslandres acting on a suggestion due to Janssen, for the purpose of photographing at one exposure the chromosphere and prominences, as well as the disc of the sun itself, in the light of the K line.

These photographs thus give us in K light the phenomena which one of us first observed by the lines C and F of hydrogen, and thereby present a record of the prominences across the whole disc of the sun as well as at the limb.

In such photographs near sunspot maximum, the concentration of the prominences in zones parallel to the equator is perfectly obvious at a glance. Eruptive or metallic prominences are thus seen to cover a much larger area than the spots, so that we have the maximum of solar activity indicated, not only by the increased absorption phenomena indicated by the greater number of the spots, but by the much greater radiation phenomena of the metallic prominences; and there seems little doubt that in the future the measure of the change in the amount of solar energy will be determined by the amount and locus of the prominence area.

Spots are, therefore, indications of excess of heat, and not of its defect, as was suggested when the term "screen" was used for them. We know now that the spots at maximum are really full of highly heated vapours produced by the prominences, which are most numerous when the solar atmosphere is most disturbed.

The Indian meteorologists have abundantly proved that the increased radiation from the sun on the upper air currents at maximum is accompanied by a lower temperature in the lower strata, and that with this disturbance of the normal temperature we must expect pressure changes. Chambers was the first to show that large spotted area was accompanied by low pressures over the land surface of India ("Abnormal Variations," p. 1).

Passing, then, from the consideration of individual spots to the zones of prominences, with which they are in all probability associated, it is of the highest interest to note the solar latitudes occupied when the crossings previously referred to took place, as we then learn the belts of prominences which are really effective in producing the increased radiation. The area of these is much larger, and therefore a considerable difference of radiation must be expected.

The greater disturbance of certain zones of solar latitude seems to be more influential in causing the + pulse than the amount of spotted area determined from spots in various latitudes.

It is all the more necessary to point this out because the insignificance of the area occupied by the spots has been used as an argument against any easily recognised connection between solar and terrestrial meteorological changes.[1]

Assuming two belts of prominences N. and S., 10° wide, with their centres over Lat. 16°, a sixth of the sun's visible hemisphere would be in a state of disturbance.

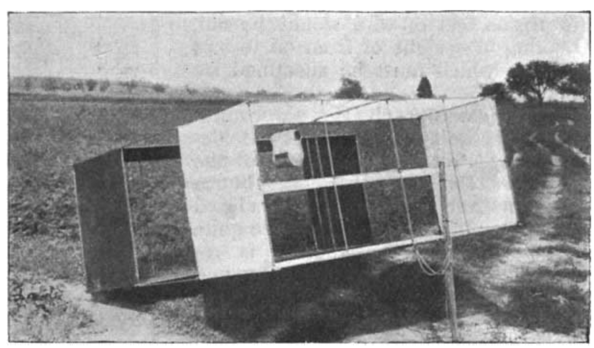
(*To be continued.*)

1 *P.R.S.*, 17, p. 415.

2 "Catalogue of Bright Lines in the Spectrum of the Chromosphere" (1872).

THE KITE WORK OF THE UNITED STATES WEATHER BUREAU.

EARLY in the year 1898, the Congress of the United States granted a sum of money, to be expended under the direction of the Chief of the Weather Bureau, for the establishment and maintenance of a series of stations at which observations of the upper free air were to be made by means of automatically recording mechanisms attached to kites. This work was to be undertaken primarily in the hope that daily simultaneous



observations might be obtained at definite altitudes, thus permitting the construction of daily synchronous charts of pressure, temperature, and wind direction and velocity, which, when studied in connection with corresponding surface charts, would admit of some advance being made in the present system of weather forecasting, both in accuracy and in the duration of the periods forecasted for.

Seventeen stations were established in the spring of

1 "So far as can be judged from the magnitude of the sun-spots, the cyclical variation of the magnitude of the sun's face free from spots is very small compared with the surface itself; and consequently, according to mathematic principle, the effect on the elements of meteorological observation for the whole earth ought also to be small" (Eliot, "Report on the Meteorology of India in 1877," p. 2).

the year 1898, mostly in the great river valleys and the upper portion of the region of the Great Lakes. The form of kite used was the Hargrave cellular (Fig. 1), with such modifications and improvements as trial and experiment dictated. The surface dimensions of the

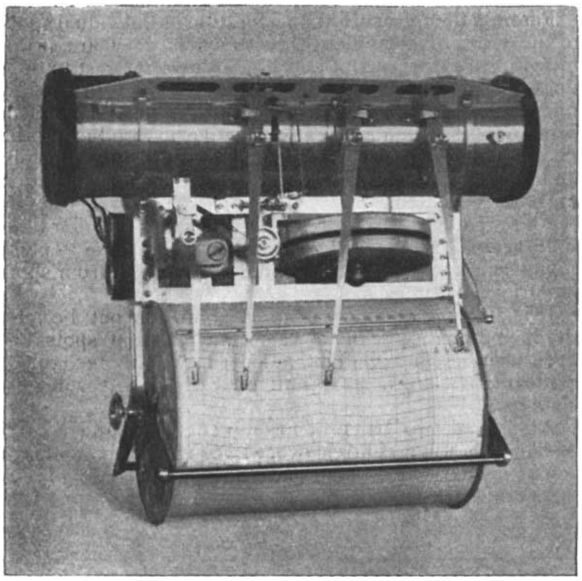


FIG. 2.—Kite meteorograph.

kites varied from 45 to 72 square feet. The kite line was carried on a large iron drum or reel, capable of resisting a crushing pressure of at least 1000 tons, and consisted of steel piano-wire ·028 inch in diameter, and weighing 2·15 pounds to the thousand feet, or 11·35 pounds to the mile. The tensile strength of this wire at the breaking-point was about 200 pounds.

With a kite flying at an elevation of from 5000 to 7000 feet, from 8000 to 10,000 feet of wire would be out, making a weight of from 90 to 115 pounds which must be sustained by the kite.

The meteorograph (Fig. 2), or automatic recording apparatus, was devised by Prof. C. F. Marvin, of the Weather Bureau. It weighs but a fraction over two pounds, is inclosed in an aluminium case, and, while quite complicated in construction, is remarkable for its compactness and lightness. The cylinders carrying the record sheets are actuated by clockwork, and four different meteorological conditions are recorded, viz., pressure, temperature, relative humidity and wind velocity (Fig. 3). The wind direction, of course, becomes apparent by observing the azimuth of the kite.

It soon became evident that there was no possibility of obtaining a daily synchronous chart. The principal difficulties were the very frequent absence of sufficient wind to sustain the kites, and inability to obtain ascensions in stormy weather. Taken as a whole, ascensions were possible during only 46 per cent. of the time from May to October, inclusive, the percentage varying from 75 at Dodge, Kansas, to 12 at Knoxville, Tennessee.

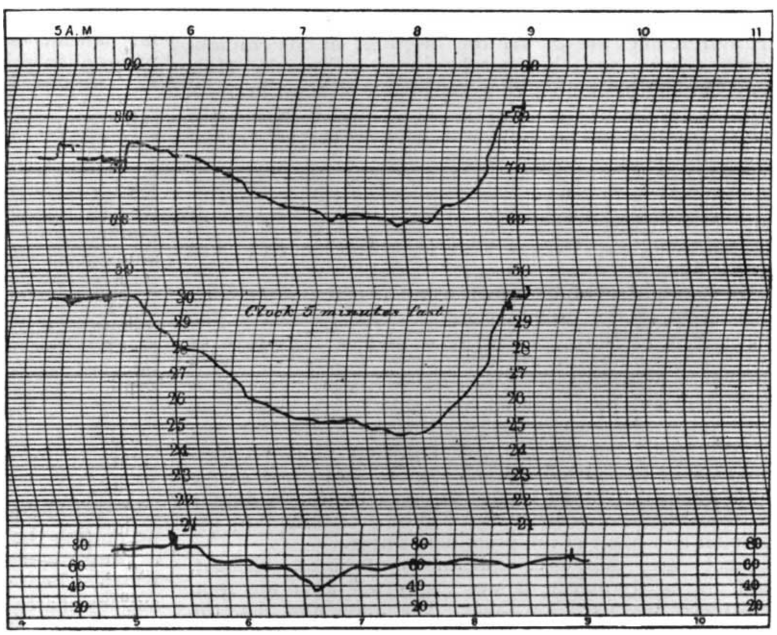


FIG. 3.—Record obtained at Arlington, Virginia, on June 14, 1898.

The hours of the day at which ascensions could be made also varied greatly.

But however disappointing the results obtained may have been from the viewpoint of the weather forecaster, they were not so when considered from another. Much valuable data was obtained from the 1217 ascensions and 3835 observations, particularly regarding vertical temperature gradients, and it is believed that there has been a very material contribution made to our previous knowledge of this subject. Briefly summarised, the results of the observations were as follows:—

The mean rate of diminution of temperature with increase of altitude was found to be 5° F. for each 1000 feet, or only 0·4° less than the true adiabatic rate. The gradient was greatest up to 1000 feet, where it was 7·4° F.; from thence up to 5000 feet there was a steady decrease to 3·8° a thousand feet, the rate of decrease varying inversely with the altitude. Above 5000 feet there was a tendency toward a slight increase.

The mean gradients on the Atlantic coast were much smaller than those in the interior, the difference being mainly due to the lower morning values of the former, those of the afternoon differing but slightly. Inversions of temperature were quite frequent, and were most pronounced when the upper air currents were from south-east to south-west. Clouds, as a rule, caused a decrease in the rate of temperature fall, sometimes so decided as to result in an actual temperature inversion. A series of observations was made at Pierre, South Dakota, during the winter of 1898–99, and a cursory examination of the records there made showed such persistent temperature inversions during periods of cold weather as to furnish convincing evidence that during a cold wave the stratum of cold air is not much over one mile in height, and frequently but little over half a mile.

The relative humidity at and above the earth's surface differed but little, and, generally speaking, the upper air percentages were the lower. The mean results were 60 and 58 per cent. respectively, a difference of 2 per cent. There were, however, some marked differences at individual stations. At Washington, D.C., it was 14 per cent.; at Omaha, Nebraska, 29 per cent.; and at Spring-

field, Illinois, 21 per cent. At Fort Smith, Arkansas, the difference was 12 per cent., but with reversed conditions, the upper air humidity being the higher.

The vapour pressures were compared with others obtained at various times at equal altitudes by means of balloons and mountain observations, and found to be somewhat lower. The average value was 59 per cent., as compared with 68 for the balloon and 66 for the mountain observations. In these data the vapour pressures were represented in percentages obtained by the formula $\frac{p}{p^o}$, p representing the vapour pressure at any given altitude, and p^o that observed simultaneously at the earth's surface.

Differences in wind direction above and at the surface were for the most part confined to a deflection toward the right at the kite. This deflection frequently increased with the altitude, but rarely exceeded 90 degrees. In some few instances, chiefly during unsettled weather, the deflection was toward the left, but not to any great extent.

At the present time efforts are being made to obtain a more improved and satisfactory vehicle for the meteorograph. If such an one can be devised, it is yet possible that the desire of the forecaster will finally be gratified with great resultant benefit both to the cause of science and to the world at large. H. C. FRANKENFIELD.

THE PRESENT CONDITION OF THE INDIGO INDUSTRY.

SINCE a previous article upon the above subject (November 1) was written, a report of the opening of the Hofmann House in Berlin has appeared in the *Times*. At the opening ceremony Prof. von Baeyer and Dr. Brunck delivered lectures upon the synthetical production of indigo. Von Baeyer's lecture dealt chiefly with the theoretical side of the question, while that of Dr. Brunck, who is one of the managing directors of the Badische Anilin und Soda Fabrik, dealt more upon the manufacturing side. As the work of von Baeyer is so well known and was referred to in the previous article, attention will only be drawn to the extremely interesting speech of Dr. Brunck.

In the first place, Dr. Brunck drew attention to the advantages of synthetic over natural or vegetable indigo, owing to its uniformity of composition, fine state of division, ready reducibility, &c. He claimed that a much less skilled operator may be employed in manipulating the dye bath than when natural indigo is used. He then went on to describe the prejudice which the synthetical indigo ("indigo pure") had to contend with when it was first placed on the market in 1897; it being stated by some that it was merely specially refined natural indigo, and by others that it was a substitute for indigo. It is extraordinary how difficult it is to make the public believe that it is possible to prepare in the laboratory a product which is identical in *every* respect to one which is of vegetable origin. In the case of indigo, however, there is perhaps some excuse, because the manufacturers of coal-tar products have often brought out colours which dye practically the same shades as indigo, but though not readily distinguished from it even by experts, have lacked one of the chief characteristics of indigo—fastness. But notwithstanding prejudice and keen competition, the development of the manufactory has been enormous. Dr. Brunck states that about 900,000*l.* has been invested in the indigo department of the Badische Company, and that the quantity of indigo now annually manufactured by this company alone would require the cultivation of nearly 250,000 acres of land in India.

The method of manufacture employed by the Badische Company is that of Heumann, in which phenylglycine-ortho-carboxylic acid (anilido-acetic acid) is fused with caustic soda (*c.f.* NATURE, this volume, p. 9). When this process was first discovered, the cost of the out-going products was so great that indigo so prepared could not compete with the natural product. *The Badische Company employ more than* 100 *highly-trained research chemists;* to some of these the work of endeavouring to elucidate the problem, how to manufacture phenylglycine-ortho-carboxylic acid cheaply, was entrusted. Taking naphthalene, which is obtained in enormous quantities from coal tar, as starting product, the following process was worked out. The naphthalene is oxidised by highly concentrated sulphuric acid in presence of mercury or mercury salts, with production of phthalic acid. The phthalic acid is then, by a series of reactions, converted into anthranilic acid which, when combined with monochloracetic acid, produces phenylglycine-ortho-carboxylic acid. During the oxidation of naphthalene with sulphuric acid large quantities of sulphur dioxide are produced, the loss of which would be a very serious expense. In preparing indigo upon the scale in which it is now manufactured, from 25,000 to 30,000 tons of sulphur dioxide are produced annually. But this is not lost; it is mixed with air and passed over heated oxide of iron, and is thus by catalytic action converted into sulphuric anhydride, and this by the action of water into sulphuric acid. Chlorine is required in order to prepare chloracetic acid, and caustic soda to fuse the phenylglycine-ortho-carboxylic acid. These two products are obtained by the electrolysis of sodium chloride. As, however, the chlorine as it is first produced is not sufficiently pure, it is purified by condensing it to the liquid condition. Attention has been drawn to the details of the manufacturing process, in order to show what a determined and powerful competition the Indian indigo producer has to face.

Synthetical indigo is being used in this country, but there is a considerable difference of opinion as to whether it is as easy to dye with the artificial as with the natural product. Some dyers state that there is a difficulty in obtaining the requisite bloom and that, therefore, materials dyed with it have a flat or dead appearance; other operators seem to find no such difficulty. Practically the only drawback to materials dyed with indigo is that the dye is inclined to rub. Some dyers say that goods dyed with synthetical indigo rub more than when dyed with the vegetable indigo. This, again, is denied by others. There is also said to be a difficulty in reducing synthetical indigo. In print-work synthetical indigo certainly appears to possess an advantage, owing to its fine state of division and to the fact of its containing no foreign matter which might scratch and injure the rollers. Before natural indigo can be employed, it is necessary to have it in an exceedingly fine state of division, and in order to ensure this it is usually ground in a mill with water for several days. The artificial product, on the other hand, is sent into the market as a very fine powder or in the form of a paste. One drawback to natural indigo is the varying amounts of indigotin which different samples contain. Artificial indigo contains not only a very high percentage of indigotin, but practically no foreign matter.

Dr. Brunck is sanguine that the synthetical product will shortly overcome all competition and drive the natural product from the market; and in his address, with a *disinterestedness* which cannot but be admired, advises the Government of India to ascertain in what manner the land which has been employed for growing indigo may be best cultivated. If the advice of Dr. Brunck is taken, there will be no doubt as to the success of the artificial indigo. As showing the vast importance of the question to India, the following statistics are given. In Northern Behar there are from 250,000 to 300,000 acres of land devoted to the cultivation of indigo,